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Performance analysis of a channel assignment scheme in cellular communication systems

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Abstract

In cellular communication systems, channel assignment schemes are very important to improve teletraffic performance characteristics. Because of the overlapping design of the cells in cellular communication systems, a mobile user is capable of communicating with two different bases. In this paper, a new channel assignment scheme is proposed to improve the blocking probability of a cellular communication system. The blocking probability of the cellular communication systems is analyzed based on Markov chain. According to the analytical results, the proposed channel assignment scheme shows different characteristics in comparison with fixed channel assignment scheme.

Keywords: Channel assignment; Cellular system; Handoff

1. Introduction

The rapid growth in the demand for mobile communications has led to research and development towards new cellular systems. In general, the handover provides continuation of calls as the mobile user travels across cell boundaries, where new channels are assigned by new bases. The performance characteristics of a cellular system include the blocking probability of new calls, the blocking probability of handoff calls, and the total carried traffic. A mobile user will request a handoff when its received signal strength is below a threshold level or another base station exists which can provide a higher received signal strength. In selecting a channel assignment scheme, the objective is to achieve a high degree of utilization and reduce the blocking probability of new calls and handoff calls. Improving the blocking probability of new calls and handoff calls is certainly one of the major challenges in cellular system design.

In cellular communication systems, channels are allocated to bases by various channel assignment schemes. In fixed channel assignment scheme (FCA) specific groups of channels are assigned to a base in such a way that the base can assign channels to users independently. Because of the overlapping design of the cells in a cellular system, a mobile user is capable of communicating with more than two bases.

Channel assignment and bandwidth reservation to support handoff have been previously studied [1–12]. Lin [2] proposed a channel assignment scheme that when a handoff occurs to a base where there is not enough bandwidth a channel currently being used is divided into two subchannels. One channel is to serve the existing call that is currently using the channel, and the other channel is to serve the handoff call.

Some researches [3–6] discuss schemes based on dynamic channel assignment. In the dynamic channel assignment schemes, channels are assigned to different neighboring cells to reduce interference and to increase overall system capacity. For example, channels assigned to mobile users in progress may be reallocated to avoid neighboring cells using the same channel simultaneously.

References [7–9] consider bandwidth reservation for handoff calls to guarantee high connectivity of admitted calls. Two bandwidth-reservation schemes [7–8] proposed a fixed number of channels in each base, which are reserved exclusively for handoffs. These schemes also allow queuing of handoff requests when one of the reserved channels is available.

Some channel assignment schemes utilizing the overlapping coverage have been suggested [10–12]. Choudhury [10] proposed a generalized fixed channel assignment scheme that allows a call to be served by any of neighboring bases. Eklundh [11] proposed directed retry that allows a new call that can not be served at one base to attempt access

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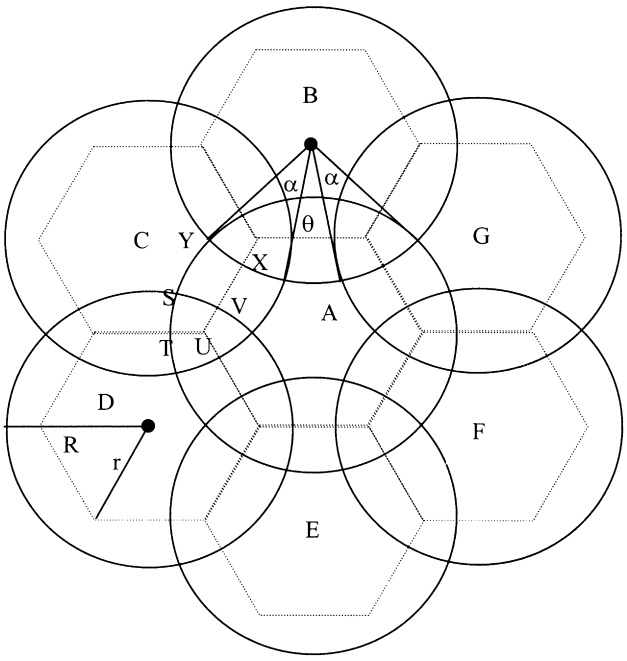

Fig. 1. System layout for overlapping coverage.

via a nearby alternate base. Karlsson [12] proposed an enhancement of directed retry, which allows calls in congested cells to be served by a neighboring cell.

Chu [13] developed an analytical model to determine blocking probability, forced-termination probability, handoff activity, and carried traffic for systems with overlapping coverage and channel rearrangement. Oliverira [14] proposed an admission control scheme based on adaptive bandwidth reservation to provide quality of service guarantees in multimedia personal communication systems. The proposed scheme provides the QoS guarantee by reserving bandwidth in cells surrounding the cell where a connection is established.

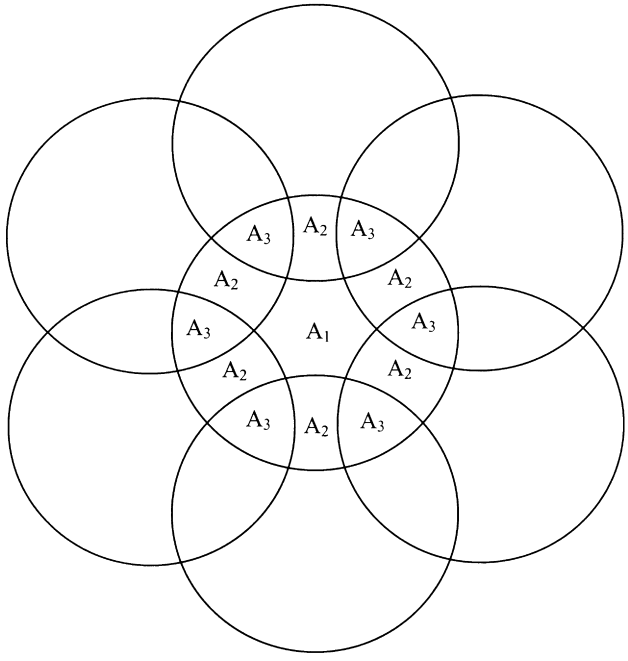

Fig. 2. Three kinds of regions in the coverage of a base.

It may be advantageous to reduce the blocking probability of handoff calls, although it may increase the blocking probability of new calls. The reason is that a fail handoff call results in interruptions of service. This paper proposed a new channel assignment scheme, which shows different performance characteristics in cellular communication systems. This paper is organized as followed. In Section 2, the proposed channel assignment scheme is described in detail. In Section 3, the blocking probability of new calls and handoff calls is analyzed. In Section 4, discussion of numerical results is provided. Section 5 gives a conclusion.

2. Proposed channel assignment scheme

Consider a cellular system consists of omnidirectional bases. As shown in Fig. 1, these bases are organized in a hexagonal pattern. Under uniform propagation and flat-terrain conditions, this corresponds to a hexagon for each base. Each base is located at the center of its own cell. Fig. 1 depicted a cellular system with seven cells. These cells are named as A, B, C, D, E, F, and G. Base A is located at the center and is surrounded by six neighboring cells. Cell radius r is defined as the distance from the center to a vertex of its own cell. The coverage area of a base is the communication area of the base. The coverage radius R is defined as the distance from the center of a base to its coverage boundary. When the coverage radius R is greater than the cell radius r, a new call arises in a cell may have access more than two bases. In this paper, the ratio of R/r is limited between 1 and 1.5 and cell radius r is normalized as one [15], thus, there are three kinds of regions in which a new call can arise within this range. As shown in Fig. 2, the regions are denoted as A_1, A_2, and A_3, respectively. A new call in region A_1 can gain access from one base. A new call in region A_2 can gain access from two bases. A new call in region A_3 can gain access from three bases. The percentage area in a cell belongs to region A_1, A_2, and A_3 is denoted as p_1, p_2, and p_3, respectively.

Suppose that there are C channels in each base. The rate of new-call arrivals is independent of the number of calls in service and the new-call arrivals follow a Poisson process with rate λ. Let $n(t)$ denote the number of calls carried by a base at time t. Dwell time is defined as the time duration that a mobile user resides within the coverage area of the base that is providing service. Dwell time is assumed to be a random variable with a negative exponential distribution of mean $1/\mu_d$. In the proposed channel assignment scheme, an arriving call is assigned a channel if the condition $((C - n(t))\lambda)/(\mu_d n(t)) > S$ is held in the cell. If the condition